Seven decades of North Atlantic storm climate statistics based on a spectrally nudged ECHAM6 simulation

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This poster shows derived statistics of a global downscaling of the NCEP re-analysis by ECHAM6 with focus on its performance of extratropical storms over the North Atlantic area. We conclude a high potential for utilizing the ECHAM6_SN simulation for comprehensive climate statistics over the past 7-decades in particular when data of high spatial and temporal resolution are useful and favored:

The global downscaling is able to hold the position of the deep pressure system and the time of occurrence as it was specified in the re-analysis. The deep pressure system appear more realistic in the ECHAM6_SN simulation compared with its forcing NCEP/NCAR, with an increase in the wind speed along the cold front and a sharpening of the structure of the deep pressure system.

Figure 1 shows a snapshot of a single simulated time step for 10 m wind speed (top) and SLP (bottom) in the different model resolutions of NCEP/NCAR and ECHAM6_SN and for comparison of ERA Interim and ERA5 demonstrating the added value of high spatial resolution in terms of resolving the physical structure of a typical extratropical cyclone.

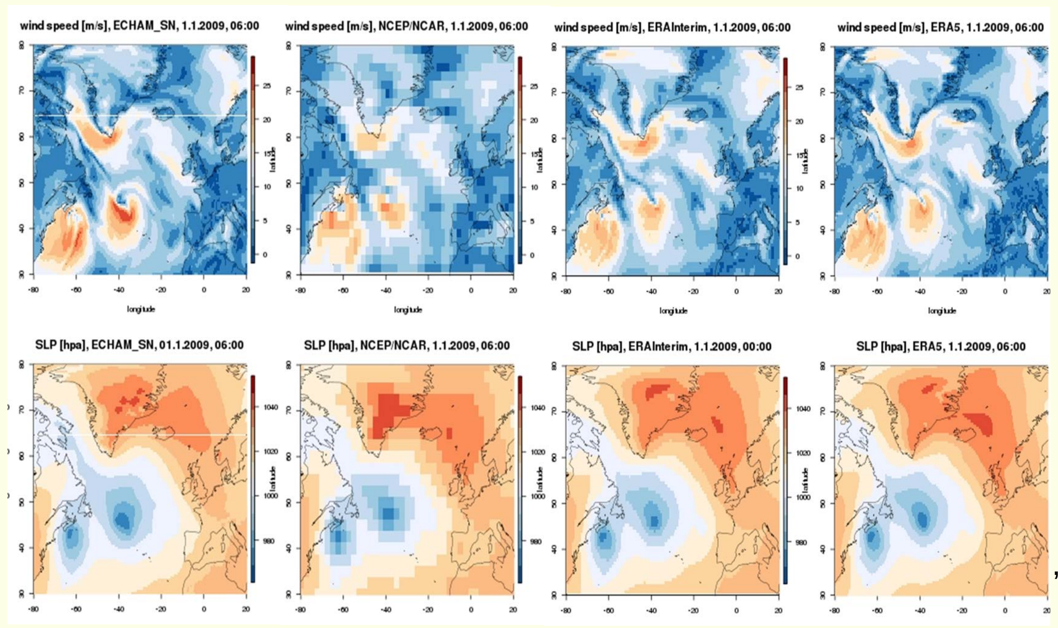

Figure 1: Snap shot of one time step of simulated wind speed (top) and SLP (bottom). From the left to the right: ECHAM6_SN, NCEP/NCAR, ERA Interim and ERA5..

Method of global downscaling with spectral nudging:

Echam6 was used to conduct a global downscaling simulation of the NCEP/NCAR re-analysis enhancing the spatial resolution from T65 to T255 (Schubert-Frisius et al., 2016). To preserve the large scale information of NCEP/NCAR, ECHAM6_SN was spectrally nudged towards vorticity and divergence using a plateau shaped vertical profile starting at 750 hpa up to 3 hpa.

Schubert-Frisius, M., F. Feser, H. von Storch, and S. Rast, 2016: Optimal spectral nudging for global dynamic downscaling, Mon. Wea. Rev., 145(3), doi:10.1175/MWR-D-16-0036.1

Storm track density, deep sea level pressure and high wind speed statistics, 2008-2014

Figure 2 shows a comparison of statistics in vicinity of extratropical storm events. From the left to the right: ECHAM6_SN, NCEP/NCAR, ERA Interim and ERA5. Shown are averages from 2008 to 2014:

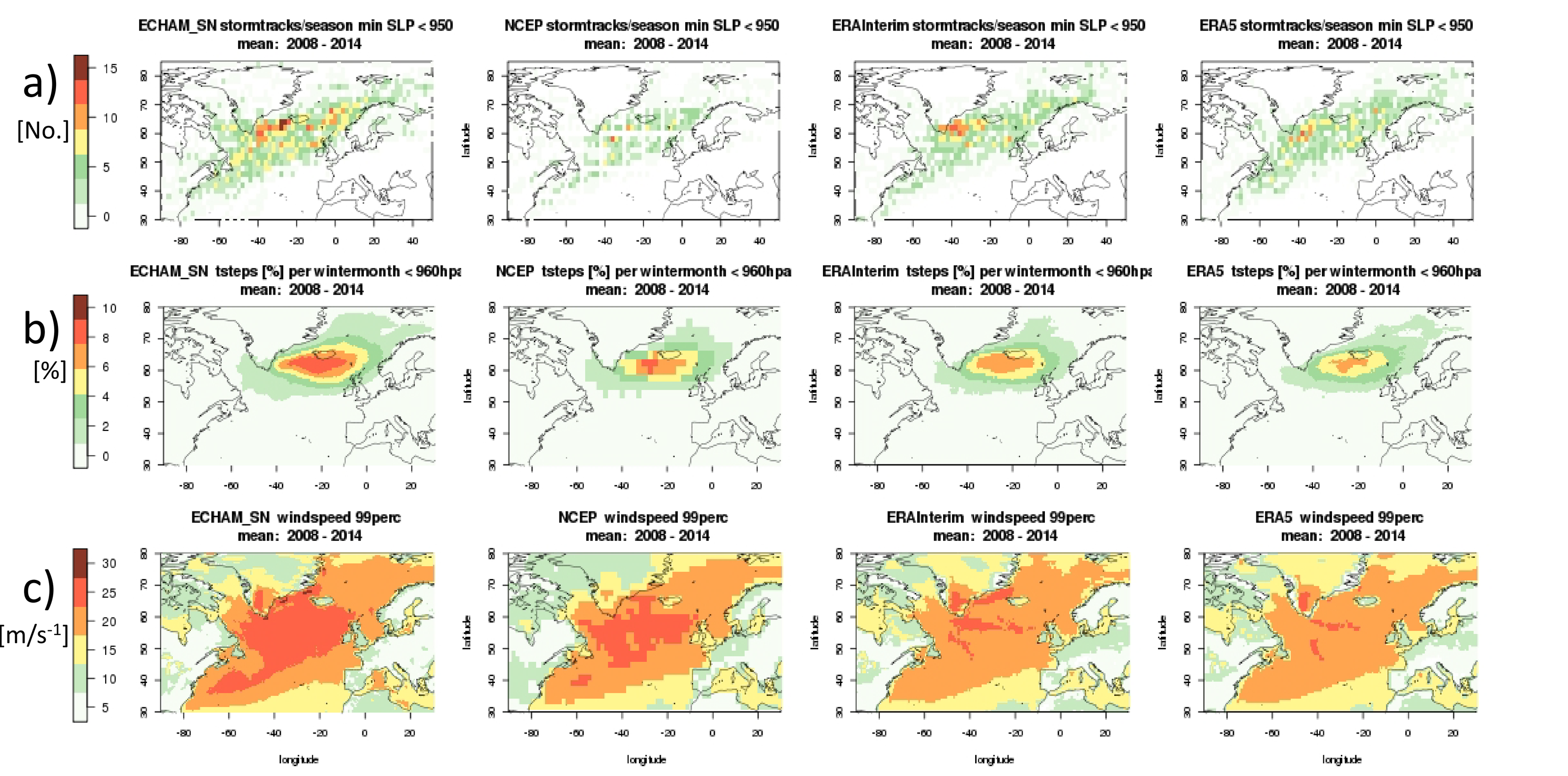

Figure 2 All calculations base on 6 hourly data and are averaged over the period 2008-2014:
a) mean annual storm track density for storm season oct-march b) percentage of time steps where SLP < 960hpa (DJF) c) 99-%-ile wind speed (DJF)

The number of tracked storms has been raised considerable in ECHAM6_SN compared to its forcing NCEP/NCAR, as well as the number of time steps with SLP below 960 hpa and the value of the 99%-ile wind speed.

Number of storm tracks per winter season: 1948-2014

Figure 3 shows the number of tracked storms for each storm season over the North Atlantic area from 1956 to 2014 with the main limiting tracking criterion, that a storm has to reach at least once a sea level pressure minimum below 950 hpa. The tracking was done standardized on 6 hourly data and 0.7 deg grid resolution.

Although the statistics of SLP and wind speed is very similar in ERA Interim and NCEP (fig. 2), the number of tracked storms per winter season is smallest in NCEP. ERA5 tracking reveals the second most storm events per season although deep SLP and high wind speed are the lowest when compared to the other three simulations.

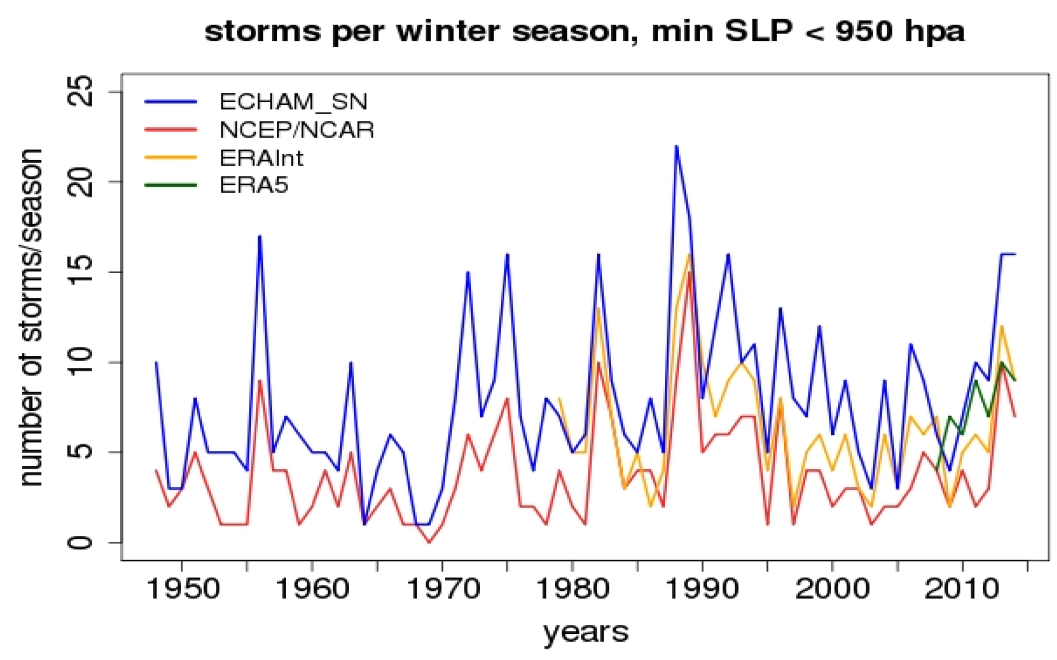

Figure 3:
Number of tracked storms (min SLP < 960hpa) for each storm season (oct-march) over the North Atlantic area from 1948 to 2014 for different reanalysis and ECHAM6_SN

Tracking of individual storms is highly dependant upon the original spatial resolution revealing a high inter decadal variability of severe North Atlantic storms.

Anomalies of storm track per season: ECHAM6_SN, 1948-2014

Figure 4a shows the anomalies of the number of storms as shown in figure 2a in time as average over longitude (a) and latitude (b). Inter-annual differences were standardized. Units: standard deviation.

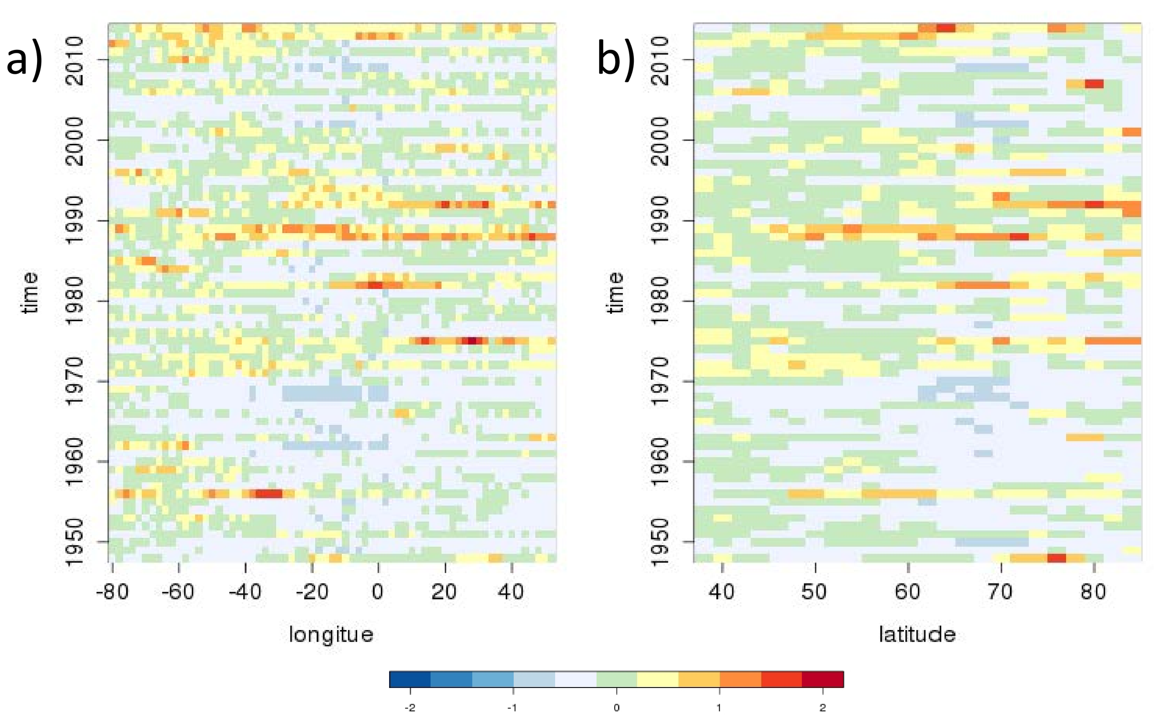

Figure 4:
standardized anomalies from the mean number of storm tracks, relative to 1970-2000.
a) latitudinal average (38-85N),
b) longitude average (-80,50E)

Number of storms change from year to year is in a range of < 1 standard deviation.
No systematic increase or decrease in storm track location to the North (b) in recent years.

DWD observations and ECHAM6_SN: Storm tracks per winter season: 1956-2014

Figure 5a shows the number of tracked storms (SLP min < 950 hpa) derived from ECHAM6_SN and the number of storms manually derived from DWD weather charts, likewise with a minimum pressure from at least 950 hpa.

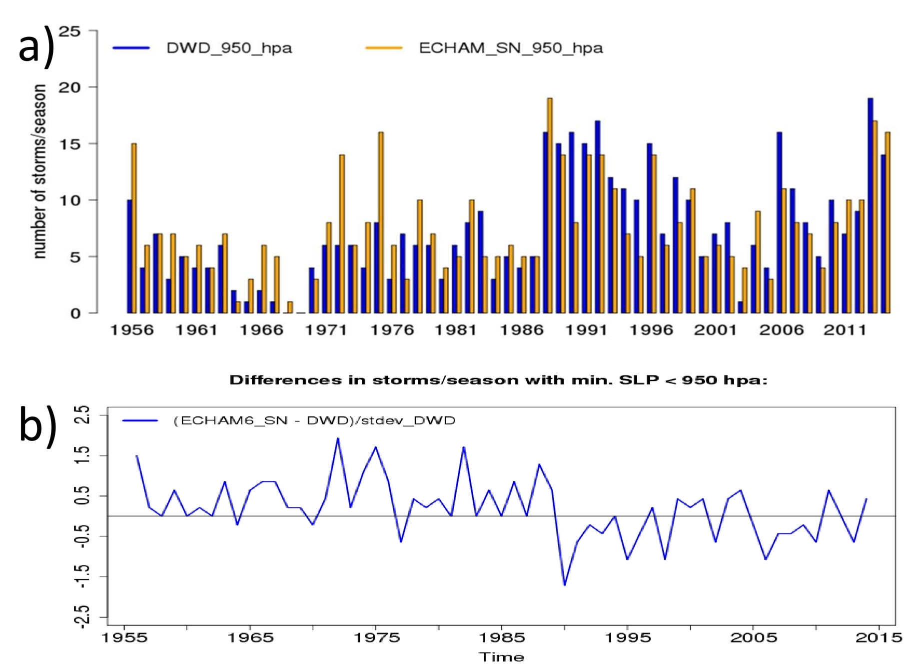

Figure 5:
Number of storms per season (oct-march) with min. criterion SLP < 950hpa, Area: North Atlantic. DWD: manually derived from weather charts; ECHAM_SN: derived with tracking algorithm

Data DWD: R. Franke, 2009: Die Nordatlantischen Orkantiefs seit 1956

The long term variability and absolute number of storm tracks per storm season is in good agreement between both methods (a).
It seems that a shift occurs around 1990 either in the manually derived DWD storm count or in the ECHAM6_SN simulation as it is pronounced in the difference plot (b).

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